

RESEARCH PUBLICATIONS ON SPACECRAFTS (1999-2013): A BIBLIOMETRIC STUDY

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ABSTRACT

This study presents the bibliometric analysis of literature on Spacecrafts during the year 1999-2013. The data for the study has been downloaded from the Scopus database. The study analyses and discusses on the yearly publications, authorship pattern, co-authorship index, citation pattern, highly contributed authors, various indices used for the top ranking authors, affiliations, core journals, etc. Burrows J.P. has contributed 308 publications during the study period and his publications received a maximum number of 7491 citations and 'h' index of the author is 42, which is highest during the study period. Geophysical Research Letters Journal has published a maximum number of 3235 articles in the field of study.

KEYWORDS: Bibliometrics, Spacecrafts, Authorship Pattern, Citation Pattern, Ranking Indices, Scopus Database

INTRODUCTION

The aim of the study is to find out the latest global trend on spacecraft research outputs. Even though the authors are in the process of studying the research output on spacecrafts for the past 40 years, they highlighted the trend for the last 15 years because of its rapid growing nature during the period.

Bibliometrics

Bibliometrics is the application of mathematical and statistical methods to publications. Bibliometrics is often used to assess scientific research through quantitative studies on research publications. The term was coined by Alan Pritchard in his 1969 paper entitled "Statistical Bibliography or Bibliometrics" in which he defined the term as "the application of mathematics and statistical methods to books and other media of communication" (Pritchard, 1969)²⁰. The first review on bibliometric empirical laws was done by Fairthorne in 1969, the quantitative treatment of the properties of recorded discourse and behavior pertaining to it (Fairthorne, 1969)⁸.

Spacecrafts

A spacecraft is a vehicle, or machine designed to fly in outer space. Spacecraft are used for a variety of purposes, including communications, earth observation, meteorology, navigation, space colonization, planetary exploration, and transportation of humans and cargo. On a sub-orbital spaceflight, a spacecraft enters space and then returns to the surface, without having gone into an orbit. For orbital spaceflights, spacecraft enter closed orbits around the Earth or around other celestial bodies. Spacecraft used for human spaceflight carry people on board as crew or passengers from start or on orbit (space stations) only, while those used for robotic space missions operate either autonomously or telerobotically. Robotic spacecraft used to support scientific research are space probes. Robotic spacecraft that remain in orbit around a planetary

body are artificial satellites. Only a handful of interstellar probes, such as Pioneer 10 and 11, Voyager 1 and 2, and New Horizons, are currently on trajectories that leave our Solar System.

Methodology

The data has been downloaded from the Scopus database. The study covered a period of 15 years from 1999 to 2013. The following search string is used to download the data from the database. The search includes the synonymous words of Spacecrafts to cover the area to the maximum possible extent on related literature.

(TITLE-ABS-KEY (Spacecrafts) OR TITLE-ABS-KEY (Rockets) OR TITLE-ABS KEY (Satellites) OR TITLE-ABS-KEY ("Space Vehicles") OR TITLE-ABS-KEY ("Space Shuttles"))

Statistical tools like Ratio of Growth (RoG), Compound Average Growth Rate (CAGR), Relative Growth Rate, Doubling Time (Dt()) has been used to analyse the growth of literature during the study period. Bibliometric indicators like authorship pattern, co-authorship index, citations pattern were analysed in the study. Also, various indices were used to rank the top authors with their affiliations, core journals with maximum publications on the related literature were analysed. For analysis and making tables SPSS and Excel software has been used for the study.

REVIEW OF LITERATURE

Malathy, S and Kantha, P. (Malathy, S and Kantha, P 2015)¹⁷ studied the bibliometric analysis of the Journal of Spacecraft Technology during 1991-2012. The analysis was made on different parameters like yearly publications of articles, authorship pattern of contributions, author productivity, degree of collaboration among co-authors and genderwise distribution of articles. The study further includes publications by affiliations, contributions by groups, ranked list of productive authors, citation pattern, etc. The study provides the insight and development of the journal towards excellence.

Nageswara Rao, K., et al (Nageswara Rao, K. et al 2014)¹⁹ studied the bibliometric analysis of the Journal of Propulsion and Power for the period 1983-2013. The study assessed the growth pattern, authorship pattern and Institutional productivity and geographical distribution of output. The study finds that the highest numbers of articles were produced during the year 1992 with 194 and lowest in the year 1987 with 81 articles. Out of the total 4047 articles produced, 1330 articles were produced by two authors and 1098 were produced by three authors. It also finds that Purdue University has contributed the highest number of 163 articles. Out of the top 21 Institutions which produced more than 50 articles, 18 were from USA. USA has produced the highest number of 2672 articles. International collaboration was involved in 287 articles and out of these 171 articles was produced by USA in collaboration with other countries. It also found that Fleeter, S from Purdue University has contributed the highest number of 54 articles.

Aswathy, S and Gopikuttan, A (Aswathy, S and Gopikuttan, A 2014)⁵ has studied the scientometric analysis of the research output in spacecraft propulsion during the period 1999-2012 with special reference to the Web of Science database. They studied and analysed the Indian contribution to the literature. The study also includes year-wise, language-wise, type of document-wise and country-wise distribution of literature. They further analyzed the Institutional-wise categorization, Degree of Collaboration and verified the Bradford's law of Scattering.

Aswathy, S and Gopikuttan, A (Aswathy, S and Gopikuttan, A 2012)⁴ studied the bibliometric analysis of Journal of Spacecrafts and Rockets during the period 2006-2010 and analyzed the growth pattern, authorship pattern, distribution with respect to year, Institution and Geographical Area. They also analyzed the citation pattern, most productive year,

lengthwise analysis, degree of collaboration of authors and Lokta's law to find the author productivity. The major finding of the study is that the Universities are the most productive sector and that the most productive country is USA.

Samuel Arbesman and Gregory Laughlin (Arbesman, S and Laughlin, G 2010)³ studied Scientometric Analysis to find out discovering of new planets. They developed novel metric habitability for discovered planets and used the study to arrive at a prediction for discovering the first habitable planet. Further the former studied the exponential increase or more properly logistic growth curve.

Objectives of the Study

- To study the publication trend on Spacecrafts during the period 1999-2013.
- To study the Ratio of Growth (RoG), Compound Average Growth Rate (CAGR), Relative Growth Rate, Doubling Time (Dt()) on the publications.
- To study the authorship pattern, Degree of Collaboration (DC), Collaboration Index (CI), Collaborative Coefficient (CC), Modified Collaborative Coefficient (MCC), Co-authorship index,
- To study citation pattern on publications including Relative Quality Index (RQI) in the area of study
- To find the top ranking authors using various indices
- To find the core journals in the field of spacecraft literature

DATA ANALYSIS

Total Productivity

The following table illustrates the annual output publications during the year of study 1999-2013.

Table 1: Quantum of Literature from 1999 To 2013

S.No.	Year	Tp	%	Rog	Cagr	Rgr	Dt
1	1999	7856	3.23	-	0.07	-	-
2	2000	9527	3.91	1.212704	0.06	0.79	0.87
3	2001	9556	3.92	1.003044	0.07	0.44	1.58
4	2002	10549	4.33	1.103914	0.06	0.33	2.10
5	2003	12573	5.16	1.191867	0.05	0.29	2.40
6	2004	15612	6.41	1.241708	0.04	0.27	2.55
7	2005	16709	6.86	1.070266	0.03	0.23	3.06
8	2006	16980	6.97	1.016219	0.03	0.19	3.70
9	2007	17779	7.30	1.047055	0.03	0.16	4.21
10	2008	20483	8.41	1.15209	0.01	0.16	4.30
11	2009	20003	8.21	0.976566	0.02	0.14	5.11
12	2010	20459	8.40	1.022797	0.02	0.12	5.68
13	2011	21222	8.71	1.037294	0.01	0.11	6.16
14	2012	22070	9.06	1.039959	0.00	0.11	6.60
15	2013	22155	9.10	1.003851	0.00	0.10	7.27
	Total	243533	100	10.99224		0.69	1.00

TP- Total Publications

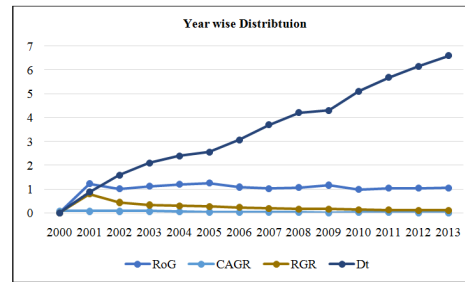


Figure 1: Growth Ratios Vs Year

From the table 1, it is found that there are 243533 total publications on the research area during the study period 1999-2013. The publication is in increasing trend over the period except in the year 2009. The productivity is highest in the year 2013 with 22155 publications and the lowest is in the year 1999 with 7856 publications. The ratio of growth (RoG) of literature is above 1 for all the years except 2009. The Compound annual growth rate (CAGR) decreased from 0.07 in 1999 to 0.10 in 2013. The Relative Growth Rate (RGR) (Hunt, R, 1978)¹³ (Blackman, V.H., 1919)⁶ decreases from 0.79 in 2000 to 0.10 in 2013. The average relative growth rate for the study period is 0.69. The doubling time (Dt) (Mahapatra, M 1985)¹⁸ of the research output on spacecrafts decreases from 0.87 in 2000 to 0.727 in 2013. The doubling time of publication has shown decreasing trend due to increase in publication.

Authorship Pattern

Table 2: Authorship Pattern

Year	Single Author	Two Authors	Three Authors	Four Authors	>4 Authors	Total	DC	CI	CC	MCC
1999	1779	1700	1577	1012	1788	7856	0.77	2.91	0.52	0.54
2000	1960	2124	1888	1346	2209	9527	0.79	2.97	0.54	0.56
2001	1876	2111	1903	1342	2324	9556	0.80	3.01	0.54	0.57
2002	1953	2304	2137	1499	2656	10549	0.81	3.06	0.55	0.58
2003	2726	2566	2460	1783	3038	12573	0.78	2.99	0.53	0.55
2004	3415	3008	3012	2173	4004	15612	0.78	3.02	0.53	0.56
2005	3536	3365	3275	2361	4172	16709	0.79	3.02	0.54	0.56
2006	3117	3305	3415	2585	4558	16980	0.82	3.13	0.56	0.58
2007	3080	3448	3607	2820	4824	17779	0.83	3.16	0.57	0.59
2008	2805	3968	4248	3465	5997	20483	0.86	3.29	0.60	0.62
2009	2597	3760	4232	3526	5888	20003	0.87	3.32	0.60	0.63
2010	2540	3777	4360	3614	6168	20459	0.88	3.35	0.61	0.63
2011	2531	3902	4327	3768	6694	21222	0.88	3.39	0.61	0.64
2012	2259	3997	4751	3989	7074	22070	0.90	3.44	0.63	0.65
2013	1938	3872	4759	4113	7473	22155	0.91	3.51	0.64	0.67
Total	38112	47207	49951	39396	68867	243533	0.84	3.22	0.58	0.61

The study of authorship pattern or productivity is one of the important aspects in the scientometric analysis.

Author collaboration can be measured with the following indicators:

- Authorship pattern i.e. Single, Multiple authors Frequency
- Degree of Collaboration (DC)
- Collaboration Index (CI)
- Collaborative Coefficient (CC)

- Modified Collaborative Coefficient (MCC)

It is observed from the above table, there are 38112 (15.64%) single authored publications. The maximum contributions are from above four authors i.e., 68867 (28.27%) out of the total publications. The maximum contribution by single authored publications is in the year 2005 with 3536 contributions. Similarly in the case of two authored publications the maximum productivity is in the year 2012 with 3997 contributions, 4759 contributions in the year 2013 for the three authors contributions, 4113 in the year 2013 for four authors and 7473 in the year 2013 for more than four authors.

The value of Degree of Collaboration (DC) (Subramanyam, K 1993)²² is maximum in the year 2013 with 0.91 and minimum in 1999 with 0.77. The degree of collaboration is in increasing trend from 1999 to 2002 (0.77 to 0.81) then it is decreasing to 0.78 in the year 2003 and stays unchanged in the year 2004. Then it shows some increase in trend till the year 2013 with a value of 0.91. The trend of collaboration index is more or less similar to that of Degree of Collaboration. The value of Collaboration Index (CI) (Ajiferuke, I. Burrel, Q & Tauge, J 1988)¹ is maximum in the year 2013 with 3.51 and minimum in the year 1999 with 2.91. The Collaboration Index increases in the first four years and then decreased in the fifth year and again it is increasing till 2013. From the above table it is learnt that the value of Collaborative Coefficient (CC) (Ajiferuke, I. Burrel, Q & Tauge, J 1988)¹ is maximum in the year 2013 with a value 0.64 and minimum with 0.52 in the year 1993. The value of Modified Collaborative Coefficient (MCC) (Ajiferuke, I. Burrel, Q & Tauge, J 1988)¹ is varies from 0.54 in the year 1999 and 0.67 in 2013. From the above table, it is concluded that collaboration work increases with respect to increase in publications and multi authored contributions outnumbered single author contributions during the study period.

The value of Co-Authorship Index (CAI) (Garg, K.C and Padhi, P., 2002)¹⁰ is determined by calculating proportionately the publications by single, two and multi authored papers and it is first used by Guan J and Ma N. (2007)¹¹. CAI = 100 implies that a country's co-authorship effort for a particular type of authorship corresponds to the world average, CAI > 100 reflects higher than average co-authorship effort and CAI < 100 lower than average co-authorship effort by that country for a given type of authorship pattern. The technique has been applied in the study and the values are given in the following table (table 3).

Table 3: Co-Authorship Index Vs Year

Year	Single Author CAI	Two Authors CAI	Three Authors CAI	Four Authors CAI	> 4 Authors CAI	Total
1999	145	112	98	80	80	7856
2000	131	115	97	87	82	9527
2001	125	114	97	87	86	9556
2002	118	113	99	88	89	10549
2003	139	105	95	88	85	12573
2004	140	99	94	86	91	15612
2005	135	104	96	87	88	16709
2006	117	100	98	94	95	16980
2007	111	100	99	98	96	17779
2008	88	100	101	105	104	20483
2009	83	97	103	109	104	20003
2010	79	95	104	109	107	20459
2011	76	95	99	110	112	21222
2012	65	93	105	112	113	22070
2013	56	90	105	115	119	22155
Total	100	100	100	100	100	243533

The co authorship index for the single author publications is higher than the average value in the year 1999-2007 and it is lower than the average value between 2008 and 2013. Similarly for the two author publications the co authorship index is higher than the average value for the period 1999 and 2003 and below than the average value in the year 2003 and again it is higher than the average between 2005 and 2008, once again it is below the average value for the period 2009 and 2013. For the three authors, four authors and more than four authored publications the co authorship index is lower than the average value between 1999 and 2007 and higher than the average value for the remaining period i.e. between 2008 and 2103. From the table it reveals that the CAI is higher than the average value with respect to increase in publications.

Table 4: Co-Authorship Index Vs Country

S.No.	Country	Single	Cai	Two	Cai	Three	Cai	Four	Cai	> 4	Cai	Total
1	US	10689	98	15758	117	13412	94	9724	86	20072	102	69655
2	China	1023	21	5074	86	8611	137	8365	169	7524	87	30597
3	Japan	1335	66	2070	82	2327	87	1979	94	5312	144	13023
4	Germany	1360	70	2228	93	2448	96	1999	100	4382	125	12417
5	France	1047	63	1556	75	2022	92	1782	103	4284	142	10691
6	UK	1576	99	2168	110	2071	99	1455	88	2894	101	10164
7	Italy	906	57	1504	76	2024	97	1750	107	3971	138	10155
8	Russian Federation	1251	122	1324	105	1283	96	916	87	1753	95	6527
9	India	624	62	1567	127	1746	133	1124	109	1324	73	6385
10	Canada	663	69	1548	129	1466	116	936	94	1555	89	6168
11	Others	17638	166	12410	94	12541	90	9366	85	15796	82	67751
	Total	38112	100	47207	100	49951	100	39396	100	68867	100	243533

The above table deals with the Co Authorship Index against the publications from Individual countries. In the case of single authored publications, the value of CAI is higher than the average value for the Russian Federation and it is below the average value for the remaining countries in the top 10 category. In the case of two authored contribution the CAI value is higher than the average value for the Countries US, UK, and Russian Federation, India and Canada and it is below the average value for the remaining countries. In the three authored contribution the CAI value is higher than the average value for the countries China, India and Canada and it is below the average value for the remaining countries. In the case of four authored contributions the CAI value is higher than the average value for the countries China, Germany, France, Italy and India and it is below the average value for the remaining countries. The CAI value for more than four authored contributions it is higher than the average value for the countries US, Japan, Germany, France, UK and Italy and below the average value for the remaining countries. There is no study growth or downfall in CAI for the top 10 countries during the study period.

Citation Pattern

Table 5: Citation Pattern

Year	TP	Cited Publication	Total Citation	Citation %	CPP	RQI
1999	7856	5482	137711	6.26	17.53	0.5151
2000	9527	6112	147464	6.71	15.48	0.5833
2001	9556	6341	154918	7.05	16.21	0.5569
2002	10549	7027	169268	7.70	16.05	0.5627
2003	12573	7586	180099	8.19	14.32	0.6303
2004	15612	8905	193631	8.81	12.40	0.7280
2005	16709	9104	184045	8.37	11.01	0.8197
2006	16980	9205	170073	7.73	10.02	0.9014

Table 5 – Cond.,						
2007	17779	9537	169439	7.71	9.53	0.9474
2008	20483	12195	171076	7.78	8.35	1.0810
2009	20003	11904	161133	7.33	8.06	1.1208
2010	20459	11940	135122	6.15	6.60	1.3671
2011	21222	12249	112413	5.11	5.30	1.7045
2012	22070	11372	73333	3.34	3.32	2.7173
2013	22155	9538	39075	0.02	1.76	5.1192
Total	243533	138497	2198800	100.00		

From the table it is clear that 138497 (56.87%) out of the 243533 total publications are cited and the total citations received for the cited publications is 2198800. The citation percentage shows an increasing trend in the beginning from the year 1999 to 2004 with a value 6.26% to 8.81% and it shows decreasing trend afterwards. The Citation Per Paper (CPP) shows decreasing trend during the period of study from 17.53 in 1999 to 1.76 in 2013. Relative Quality Indicator (RQI) is the ratio of the proportion of number of cited publications to total citations of the year and to the proportion of total cited publications to total citations. The measure relates to the incidence of high quality papers for a country or an institution a value of $RQI > 1$ indicates higher than average value, whereas a value of $RQI < 1$ indicates lower than average quality. The research output between 1999 and 2007 is below than the average quality whereas the publications from 2008 onwards have higher than the average value. It is concluded that the quality publications were being produced in the recent years.

Table 6: Various Indices for Top 10 Authors

S.No	Author	TP	%	TC	ACPP	h Index	g Index	hg Index	P Index	R Index	$h_{(Nom)}$ Index	e Index	a Index
1	Taverna M. A.	450	0.18	8	0.017778	1	2	1.414214	0.521982	2.828427	0.002222	2.645751	8
2	Morring Jr. F.	418	0.17	29	0.069378	2	3	2.44949	1.262428	5.385165	0.004785	5	14.5
3	Reme H.	307	0.13	6502	21.17915	39	67	51.11751	51.63988	80.63498	0.127036	70.5762	166.7179
4	Burrows J. P.	308	0.13	7491	24.32143	42	77	56.86827	56.69041	86.55056	0.136364	75.67694	178.3571
5	Russell C. T.	239	0.10	4671	19.54393	35	56	44.27189	45.0271	68.34471	0.146444	58.70264	133.4571
6	Covault, C.	222	0.09	30	0.135135	2	4	2.828427	1.59452	5.477226	0.009009	5.09902	15
7	Angelopoulos, V.	208	0.09	4005	19.25481	28	54	38.88444	42.56447	63.28507	0.134615	56.75385	143.0357
8	Scheeres, D. J.	226	0.09	2549	11.27876	27	47	35.62303	30.63447	50.48762	0.119469	42.66146	94.40741
9	Dandouras, I.	184	0.08	3265	17.74457	26	49	35.69314	38.69452	57.14018	0.141304	50.88222	125.5769
10	Glassmeier, K.	182	0.07	4253	23.36813	27	58	39.57272	46.32049	65.21503	0.148352	59.36329	157.5185

The above table shows various indices of top ten authors contributed with respect to publication during the period of study. The author Burrows J. P has secured highest rank by obtaining 42 in 'h' index. He got 7491 citations for his 308 publications followed by index by Reme with 'h' index of 39 for the 6502 citations received from his 307 publications and Russell, C. T. with 'h' index of 35, for 4671 citations from 239 publications. The above study shows that the ranking of authors is not related to the number of publications in the field and relates only with number of citations received for their contributions.

Table 7: Various Indices Rank for Top 10 Authors

S. No	Author	Rank										
		TP	TC	ACPP	h	g	hg	p	r	$h_{(Nom)}$	e	a
1	Taverna M. A.	1	10	10	10	10	10	10	10	10	10	10
2	Morring Jr. F.	2	9	9	8	9	9	9	9	9	9	9
3	Reme H.	4	2	3	2	2	2	2	2	6	2	2
4	Burrows J. P.	3	1	1	1	1	1	1	1	4	1	1
5	Russell C. T.	5	3	4	3	4	3	4	3	2	4	5
6	Covault, C.	7	8	8	8	8	8	8	8	8	8	8
7	Angelopoulos, V.	8	5	5	4	5	5	5	5	5	5	4
8	Scheeres, D. J.	6	7	7	5	7	7	7	7	7	7	7
9	Dandouras, I.	9	6	6	7	6	6	6	6	3	6	6
10	Glassmeier, K.	10	4	2	5	3	4	3	4	1	3	3

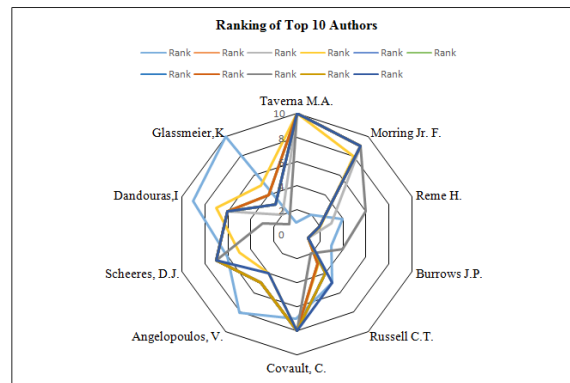


Figure 2: Ranking of Authors

Table 7 deals with the ranking of authors with respect to various indices used for this purpose in the bibliometric study. Taverna M. A tops the rank with respect to number of publications followed by Morring Jr. F and Burrows J. P. The author Burrows J. P ranked top with respect to all the indices except $h_{(nom)}$.

Prolific Authors of Literature

Table 8: Prolific Authors and Their Affiliations

S. No	Authors	Affiliations	Country
1	Taverna M. A.	Kourou French Guiana	France
2	Morring Jr. F.	NASA Kennedy Space Center, Merritt Island	United States
3	Reme H.	French National Centre for Scientific Research, The Research Institute in Astrophysics and Planetology, Toulouse	France
4	Burrows J.P.	Universitat Bremen, Institute of Environmental Physics (IUP), Bremen	Germany
5	Russell C.T.	University of California, Los Angeles, Department of Planetary and Space Science, Los Angeles	United States
6	Covault, C.	NASA Kennedy Space Center, Merritt Island	United States
7	Angelopoulos, V.	University of California, Los Angeles, Department of Earth, Los Angeles	United States
8	Scheeres, D.J.	University of Colorado at Boulder, Department of Aerospace Engineering Sciences, Boulder	United States
9	Dandouras, I.	CNRS Centre National de la Recherche Scientifique, Paris	France
10	Glassmeier, K.	Technische Universität Braunschweig, Institut für Geophysik und Extraterrestrische Physik, Braunschweig	Germany

The top ranked authors and their affiliations with respect to number of contributions were listed in the above table (Table 8). From the table it is found that authors from France, United States and Germany have contributed more number of papers in the area of study. Kourou French Guiana, Paris, France ranked top among the Institutions followed by NASA Kennedy Space Center, Merritt Island, United States and French National Centre for Scientific Research, The Research Institute in Astrophysics and Planetology, Toulouse, France.

Most Preferred Journals for Publication

Table 9: Most Preferred Journals

S. No.	Journal	Tp	%
1	Geophysical Research Letters	3235	1.33
2	Journal of Geophysical Research Space Physics	3089	1.27
3	Astrophysical Journal	2877	1.18
4	International Journal of Remote Sensing	2833	1.16
5	Advances in Space Research	2551	1.05
6	Astronomy and Astrophysics	2470	1.01
7	Journal of Geophysical Research Atmospheres	2445	1.00
8	Remote Sensing of Environment	1804	0.74
9	Acta Astronautica	1580	0.65
10	IEEE Transactions on Geoscience and Remote Sensing	1541	0.63

The Journal Geophysical Research Letters published 3235 (1.33%) publications followed by Journal of Geophysical Research Space Physics with 3089 (1.27%) and Astrophysical Journal with 2877 (1.18%) of the total publications in the most preferred journals category.

Findings

- There are 243533 publications during the study period between 1999 and 2013. The Publications output is maximum in the year 2013 with 22155 publications and minimum in the year 1999 with 7856 publications.
- It is found that 38112 (15.64%) single authored publications during the study period. Also it reveals that four and more authors contributed 68867 (28.27%) maximum number of publications.
- It is found that 138497 (56.87%) publications out of the total 243533 publications were cited and received 2198800 citations. The RQI is above average from the year 2008 onwards shows that more number of quality research output is being produced during the recent years.
- Taverna, M. A., contributed 450 publications and ranks top in the highest number of publications category.
- Burrows, J.P. has contributed 308 publications during the study period and his publications received a maximum number of 7491 citations. The authors tops in 'h', 'g', 'hg', 'p', 'r', 'e', 'a' indices.
- The Geophysical Research Letters Journal has published a maximum number of 3235 articles (1.33%) out of the total publications which is most preferred journal among the researchers in the field of study.

CONCLUSIONS

The research productivity shows an increase in trend throughout the study period except in the year 2009. Doubling time decreases throughout the study period due to increase in publications. Multi-authored contributions outnumbered single author one shows that collaborative research works gets priority. The quality of the research output has increased in the recent years. Quality publications determine the ranking of authors. More number of research works is being carried out in the area of research in the top ten countries when compared to the rest of the Nations.

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